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Patents Form 1/77

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9913843.0

The Patent Office

Cardiff Road
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1. Your reference

   HRW/sb/ANR02

2. Patent application number
   (The Patent Office will fill in this part)

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Anritsu Limited
   Rutherford Close
   Stevenage
   Hertfordshire
   SG1 2EF

   Patents ADP number *(if you know it)*

   07679145001.

   If the applicant is a corporate body, give the country/state of its incorporation

   UK

4. Title of the invention

   Testing Mobile Phones

5. Name of your agent *(if you have one)*

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   BROOKES & MARTIN
   HIGH HOLBORN HOUSE
   52/54 HIGH HOLBORN
   LONDON WC1V 6SE

   Patents ADP number *(if you know it)*

   471001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

   Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	-
Description	9
Claim(s)	-
Abstract	-
Drawing(s)	2 x2

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Priority documents	-
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature ..... Date

BROOKES & MARTIN 11 June 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

Hugh R Wright 01892 510600

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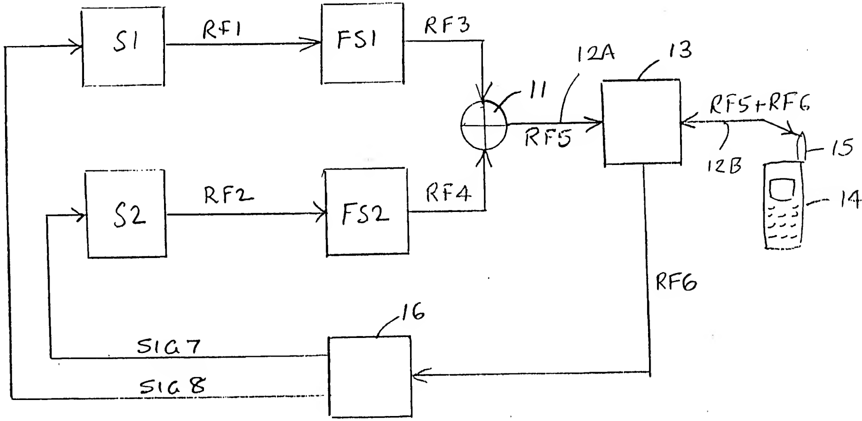
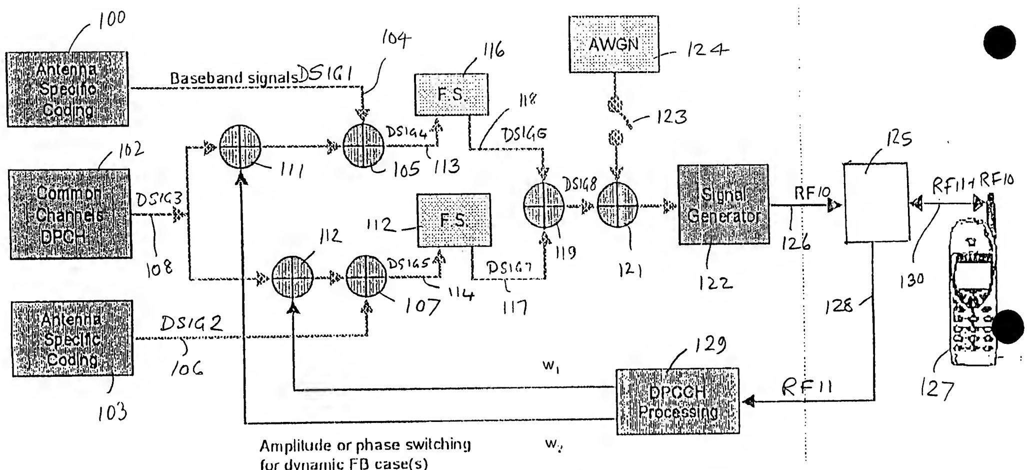

S1
RF1
FS1
RF3
S2
RF2
FS2
RF4
11
12A
13
RF5
RF5+RF6
12B
15
14
RF6
16
SIG7
SIG8

FIG 1

FIG 2


Antenna Specific Coding
100
Common Channels DPCH
102
Antenna Specific Coding
103
Baseband signals
DSIG1
DSIG2
DSIG3
DSIG4
DSIG5
DSIG6
DSIG7
DSIG8
104
105
106
107
108
111
112
113
114
F.S.
116
117
118
119
121
AWGN
124
123
Signal Generator
122
RF10
126
125
RF11+RF10
130
127
128
RF11
DPCCH Processing
129
w_1
w_2
Amplitude or phase switching
for dynamic FB case(s)

TESTING MOBILE PHONES

The present invention relates to the testing of cellular mobile phones and in particular a method for testing third generation (3G) cellular mobile phones. 3G cellular radio systems will employ a new technique called Tx diversity in order to improve reception and increase the overall efficiency of the network. Two or more transmitter antennae will be used at each base station.

It is well known that mobile phone communications are provided by transmission of signals in both directions between an antenna at a base station and a mobile phone. Conditions may vary in the path between the base station and the mobile phone and this can create problems, such as fading. In first generation (analog) mobile telephony, the rate of information fed along the channel from the base station to the mobile phone (and vice versa) is relatively slow and the delay spread caused by changes in the environment between the base station and the mobile phone is less than one data symbol. For example, the delay spread is usually 15 microseconds or less. Thus, a mobile phone receiver does not notice this.

However, in more recent (second generation) mobile telephony, for example GSM, the transmission rate is much faster and so it is possible for the delay spread to be of the same order of magnitude as the information rate. (Eg one piece of information every 3.6 microsecond.) As a result, the signal when received by the GSM mobile phone may include echoes. There may be many echoes because the signal may be received by the mobile phone via a variety of different paths with different environmental effects.

The mobile phone will normally deal with this by tuning to each echo and combining all or several echoes to determine the transmitted information. The echoes may exhibit time diversity, that is echoes of the same data signal may arrive at different times (out of phase) and as a result, depending on the phase relationship of the echoes, the echoes may add or subtract which can create fading or increase of the signal. If the two

echoes cancel each other out then the mobile phone, which provides an indication back to the base station of the signal strength which is it receiving, will effectively instruct the base station to increase the power output and this is undesirable for a number of reasons.

It has been proposed to overcome or reduce these problems in the 3G wireless telephony base stations by providing at some or all of the base stations two (or more) antennae usually separated by fractions or multiples of the wavelength of the signal, for example, half, one, two wavelengths and transmitting antenna specific signals such that a mobile phone can distinguish them and then feed back signals to separately correct the relevant antenna output.

The RF receiver in the 3G mobile telephone includes a system which can separate out a relevant part of the signals from the two antennae. The mobile phone measures the power and phase of the signal received from the first antenna and the power and phase of the signal received from the second antenna and transmits a signal back to the base station to cause the base station to adjust the phase and power between the two antennae so as to improve the reception at the mobile phone. In practice, each antenna transmits a signal which comprise two components, firstly a component which relates to the common information (ie traffic and typically relates to the information being transmitted to the mobile phone), and a second antenna specific signal (a pilot signal) which enables the mobile phone to distinguish which antenna is which.

The mobile phone uses the pilot signal to measure the phase and power received from each antenna and to thereby provide the information returned to the base station to adjust the output of the antennae.. Thus the mobile phone returns to the base station a complex vector signal which sets out the relationship between the pilot signals from each antenna and generally will try to get the same power and same phase from each antenna. In a typical system, the mobile phone will send sixteen hundred correction signals per second back to the base station so that as the relative strengths and phases

of the signals from each antenna vary in real time, the signals on the two antennae may be corrected so as to counter the effect of fading.

For a particular design of mobile phone to be approved for use with the system, it is necessary to be able to test that mobile phone to see whether or not it will be able to identify the signals from each antenna and sufficiently accurately measure the power and phase of the signals so as to be able to operate the system properly.

The present application relates to a method and apparatus for testing mobile phones, particularly 3G mobile phones in this way. Of course it is possible to test each individual mobile phone separately, but in practice the present arrangement is intended to be used for each particular design of mobile phone during its development so as to ensure that the design complies with the necessary standard. Such apparatus is also useful in conformance testing, research and development, as well as production.

It is preferred that the apparatus and method may simulate conditions found in real life, so that the signals between the two antennae may be set at particular static levels, and may also be dynamically varied.

A traditional approach which might be applied to testing 3G mobile phones is diagrammatically set out in Figure 1. There is provided two (or more) base station simulators (S1, S2) which each provide a relevant RF (radio frequency) signal output, RF1, RF2, each RF output signal being passed through a respective fading simulator, FS1, FS2, and thereby providing a respective new RF signal, RF3, RF4. These two RF signals are combined in a summer 11 and the combined RF signal RF5 is passed by a coaxial line 12A, 12B via an extractor 13 to the antenna input 15 of a mobile phone 14 under test. The antenna of the mobile phone 14 transmits a signal RF6 (at a different frequency to RF5) which passes to the extractor 13 where it is separated from RF5 and passed to a signal processor 16 which provides two non-RF signal outputs SIG7, SIG8, dependent upon the power and phase of RF3, RF4 respectively. These

signals, SIG7, SIG8, are passed to the base station simulators, S1, S2.

Such an arrangement, of course, replicates the system in the field, the two base signal simulators providing RF signals replicating those produced by the two antennae, and the two RF signals being summed to be passed to the mobile phone 14, and the signal RF6 replicating the return signal to the antennae. There are a number of problems associated with this arrangement and these generally relate to the summer 11, to the various coaxial cables and the extractor 13. The coaxial cable is important. The length of the coaxial cable is particularly important because there is a phase change along the length of the coaxial cable. Thus, in terms of the length of cable between S1, S2 and the summer 11 there may be an unintentional phase change, and the summer can introduce a phase change. The coaxial cable can also introduce reflections into the system. It is also difficult to accurately maintain and generate the same power outputs via two fading simulators. In practice it is necessary to measure the signal passing along the coaxial cable 11 to adjust the various components including the base station simulators S1, S2 and the fading simulators FS1, FS2 so as to provide a signal of a known desired type to the mobile phone 14.

There are similar problems in dealing with the signal RF6.

The present invention relates to a method and apparatus arranged so as to reduce or remove the above problems.

A preferred embodiment will now be described by way of example only and with reference to the accompanying drawings in which:-

Figure 2 sets out the apparatus of the invention diagrammatically.

Referring to Figure 2 there are shown three baseband (ie non-RF) digital signal generators, 100, 102, 103, signal generator 100 producing an antenna specific coding

signal DSIG1 which, relates to the pilot signal of a first antenna. The output signal DSIG1 which is digital is passed along line 104 to a multiplier 105. The baseband digital signal generator 103 produces an antenna specific coded signal DSIG2 similar to that produced by 100 but relating to the pilot signal of the second antenna. The output digital signal DSIG2 is passed via line 106 to a multiplier 107.

Baseband digital signal generator 102 is arranged to provide, in digital form, the common channel signal DSIG3 (corresponding, for example, to the traffic signal carrying, for example, the telephone message) and is passed via line 108 and multipliers 111, 112, respectively to multipliers 105, 107. The digital output signal DSIG4 of the multiplier 105 is passed via line 113 to a fading simulator 116 and the digital output signal DSIG5 of multiplier 107 is similarly passed along line 114 to a fading simulator 112. The output signal DSIG6 of fading simulator 116 is passed via line 118 to a summer 119 and similarly the output signal DSIG7 of the fading simulator 112 is passed via line 117 to the other input of the summer 119. The output signal DSIG8 of the summer 119 is passed via summer 121 to a radio frequency signal generator 122. The summer 121 is also connected via switch 123 to a noise generator, in particular, an Additive Gaussian White Noise generator 124 (which simulates traffic on the network). It will be noted that the signal input to the generator 122 is a digital baseband signal.

The RF output signal RF10 from the signal generator 122 is provided to an RF line 126 in the form of coaxial cable connected to an antenna input of a mobile phone 127 under test via a separator 125.

The radio frequency output signal RF11 from the antenna port of the mobile phone 127 when separated by separator 125 is passed by a coaxial line 128 to a processing apparatus 129.

The processing apparatus 129 processes the signal received and provides two output

signals W1 and W2 on lines 131, 132 respectively, which are passed to the other inputs of the multipliers 112, 111 respectively.

The apparatus of Figure 2 operates as follows.

A mobile phone 127 to be tested is connected to the apparatus as shown in Figure 2. The mobile phone may be a phone in the design or development phase whereby the apparatus may be used to test the efficiency of operation of the design, or alternatively, may be used to test production mobile phones.

The antenna or an antenna port of the mobile phone is connected to the coaxial line 130 by a suitable connector.

In use, the two baseband digital signal generators 100, 103 provide a respective digital baseband signal, each of which is multiplied with the common channel signal provided by the signal generator 102 at the respective multipliers 105, 107. Fading simulators 116, 117 are operated in accordance with a prearranged schedule (to be described later) and the two signals from the respective fading simulators are combined at summer 119, are furthermore combined with the white signal noise at summer 121 and the combined digital signal is used to control the RF signal generator 122 which thereby provides a signal RF10 based on the combined data signal.

In a first test procedure, the outputs of the various signal generators 100, 102, 103, and the operation of the fading simulators 116, 117, are set to preset static conditions so as to produce at 118, 117, digital signals which relate to RF signals which are of a known power level and phases which are of a known offset.

The mobile phone 127 is then tested and the relevant values determined by the phone 127 are compared with the known offset and known signal level and these must agree to within specified limits.

Before describing a second operation of the apparatus in which the fading simulators 116, 117 are operated in accordance with a prearranged schedule, which will be described later, it is convenient at this point to describe the operation of the fading simulators used in a preferred embodiment of the invention.

The fading simulators are devices which take an input signal DSIG4 or DSIG5 and produce an output DSIG6 or DSIG7 respectively in which:-

(a) the phase of the output signal is selectively varied with respect to the phase of the input signal, and the amplitude of the output signal is selectively varied with respect to the amplitude of the input signal, and/or

(b) the output signal DSIG6 or DSIG7 includes plural components which correspond to echoes, each of the plural components having a variable amplitude and variable phase with respect to the input and with respect to each other.

In essence, the input signal to the fading simulator is passed to a plurality of parallel channels each of which includes a variable delay apparatus. The delay to the signal created by the delay apparatus may either be statically arranged or the delay apparatuses may be controlled by a respective signal applied to each delay apparatus to vary the delay in a known or random manner.

The outputs of each delay are passed to a respective multiplier. Each multiplier has an input to which a complex signal is provided, the complex signal either being preset or varied in a known or random manner. The outputs of the multipliers are combined to provide a single signal output which carries a signal which has a number of components corresponding to the number of delays which thereby have independent variable amplitudes and independent variable phase shifts, and it will be understood that the amplitude and phase shifts may be static or may be changed in accordance with a known pattern, or may be changed in a random manner. Each of these signal

components will effectively correspond to a separate echo and will be handled by the mobile phone as if they were echos produced in the field.

Thus in the second operation of the apparatus, in distinction to the first operation of the apparatus in which the signal DSIG6 or DSIG7 has a number of components with a fixed relationship with respect to amplitude and phase to the input signal DSIG4 or DSIG5, the phase and amplitude of the components of the signal DSIG6 and DSIG7 will vary with time either in a random manner or in a predetermined manner. (It is useful to use a predetermined pattern of variation because this enables one then to compare different mobile phones with exactly the same signal.)

The way in which the efficiency and operation of the mobile phone is tested in this case is to arrange for the signal generator 102 to provide a prearranged digital pattern, and for the mobile phone to report the error bit rate. The error bit rate must be within predetermined limits and also it may be shown by switching off the feed back arrangements (for example by breaking the link 128) that the mobile phone when utilising the system calling the invention provides an improved error bit rate than without using the system of the invention.

It will be understood that the present invention provides an improved apparatus for testing mobile phones in this environment.

In the described arrangement, there is only a single RF signal generator 122 and the simulation of the two antennae takes place in the baseband digital domain between the signal generators 100, 102, 103 and fading simulators 116, 117. Since the signals are digital at this point, the relative level and phase can be very accurately controlled.

Since it is mainly the relative values that are important (for each antenna) and since they are all in the digital domain, the system is intrinsically accurate. Absolute levels are more easily controlled and only one RF generator is required.

The invention is not restricted to the details of the foregoing example.

The Additive Gaussian White Noise generator 124 provides a noise source which in the example shown in Figure 2 is summed in the digital domain but can if necessary be applied to the RF signal output from the RF signal generator 122. By the arrangement provided, only a single such noise source is required.